Interactive Training on Mobile Devices

Training Using Text-to-speech and Speech Recognition, on Pocket PC PDA.

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Collaborating with AC&S, Germany.

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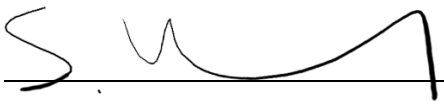
Statement of Originality

I, Stephen Howard, confirm that this work is my own achievement.

1. Where I have consulted the published work of others this is always clearly attributed.
2. Where I have quoted from the work of others the source is always given. With the exception of such quotations this dissertation is entirely my own work.
3. I have acknowledged all main sources of help.
4. If my research follows on from previous work or is part of a larger collaborative research project I have made clear exactly what was done by others and what I have contributed myself.
5. I have read and understand the penalties associated with plagiarism.

Signed  (student)

Date _____

Abstract

Research has show that PDAs, mobile phones and other mobile devices are becoming increasingly popular as tools for delivering training and education resources. The popularity as given rise to the term mLearning – mobile learning (Steve Chi-Yin Yuen, 2004, Harry Ketamo 2002 and others).

This project explores the use of PDAs as devices that can deliver highly interactive training to users. In addition to researching existing projects the developer has created a proof-of-concept application that demonstrates the potential of PDAs as tools for delivering highly interactive and engaging training applications.

The resulting product successfully shows the potential of the PDA as a method of delivery of a complete multimedia educational application.

A note about references used in this report

The internet is a valuable resource for information. Some of the reference material used in this report was sourced directly from the internet and not from academic papers. Where this is the case, a numeric reference has been used, e.g. (1), in contrast to an academic reference (Smith, 2000).

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Finally I'd like to thank my friend, colleague and business associate, Mark Tomlinson, of AC&S, who came up with the ultimate project suggestion, and who believes in my ability to produce when needed.

1 Introduction

Over the last few years the PDA has evolved from an electronic address book to a powerful and versatile pocket computer. Where once it was amazing to see one of these machines hold more than 100 names and addresses, they are now commonly used to surf the internet, read email, read books, play music, play video, read and create 'office' documents such as word processor, spreadsheet and presentation documents and control the television in place of the manufacturer's remote control and play highly interactive 3D games. With expansion cards, a high-end PDA can carry as much as 8Gb of storage. 1Mb is enough for an 800 page novel. 2Gb is ample space for thousands of documents, 25 albums worth of music, or around 25 hours of video.

The mobile phone has also evolved - from a brick-sized device, to one small enough to hide in the average pocket. The cheapest mobile phone has a sophisticated address book, can handle email, sending and receiving text and multimedia messages and will synchronise contact, calendar and message information with PC or laptop systems. "Texting occurs within and between nearly every social situation—driving, going to the theatre, attending classes—despite the abhorrently kludgey interface" (Bryan Alexander 2004). In addition to these features in 'ordinary' mobile phones, newer super phones, called Smartphones, are appearing in phone retailers. These phones combine all the power of the best mobile phones with the power of a mid-range PDA.

Owners of cell phones and PDAs do not usually know all that their devices can do because they have become very powerful devices. As the ubiquity of the PDA grows, now that every phone is essentially a PDA too, developers, users, businesses and schools are looking for ways to harness that power to improve their lives and productivity. Training is already an important target function, spawning the term mLearning, as can be seen by the wealth of academic literature on the subject.

Much of the current literature concentrates on delivering web-based content, (for instance Stephen J.H. Yang et al 2003) in part because it can be efficient in terms of file size. High-capacity, cheap memory cards mean it is possible to deliver large quantities of training to mobile devices by removing the need for an internet or network link. With individual memory card capacities are available with as much as 4Gb are affordable for consumer use, and as much as 12 Gb for the business or military applications (1), these cards have room for significant amounts of high-quality video and other multimedia. The Encyclopaedia Britannica already produces a PDA-friendly version on SD card (2).

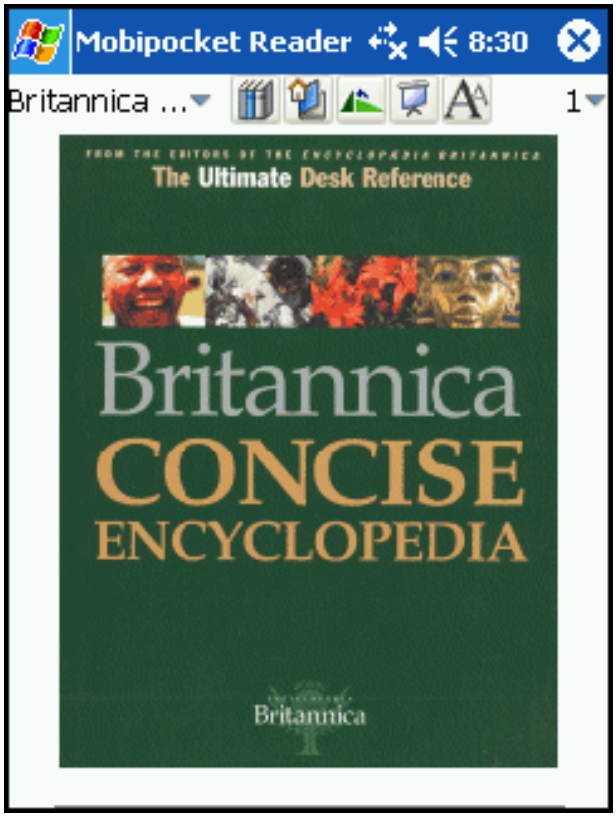

Fig 1 Britannica Concise Encyclopaedia (image from Handango.com)

AC&S (Aerospace Consulting and Services GmbH), the client for this project, also recognises the potential of the PDA as a reference and training device. They are an independent, international engineering company, supporting the civil and military aircraft industry as well as government agencies (4). AC&S has a goal of providing highly interactive, engaging training to the aircraft

and needs a sample application that demonstrates the power of the PDA to their clients.

The purpose of this project is to give AC&S that demonstration application, and to explore the academic interests of such a project, considering for instance, the complexity, usability and functionality of the device and any training delivered by it.

1.1 Background

I have had a long association with AC&S in Germany, the project sponsor. As a professional multimedia developer, I have worked for AC&S to produce a demonstration application that shows how high-quality images and animations can be used to present training and reference materials on hand-held PocketPC devices.

AC&S believes that PDAs and Smartphones are going to become ever-more popular and powerful over the next few years (4) and they are going to become more important tools for training and reference of all kinds, with predictions of enormous growth in the industry (Nancy Deviney and Christopher Von Koschembahr 2004). Specific instances include on-the-job training and reference for engineers and technicians (e.g. reference manuals for aircraft engines), corporate training and information dissemination (e.g. just-in-time training for salesmen (Nancy Deviney et al 2004) and hobbyist training for consumers (e.g. learning a language (Vaida Kadyte, May, 2003), Open University studies (Agnes Kukulska-Hulme, June, 2002), carpentry skills).

Knowing this, AC&S wants to be in the forefront as companies begin to develop high quality training that goes far beyond simply digitising existing text books.

While developing for small devices like phones and PDAs, it is important to remember that whilst they may have features and functionality similar to a three-to five-year-old PC (Jarett Smith, 2005), there are also a number of limitations presented by PDAs that are not an issue with modern PC

development (A Bridgland, P Blanchard ,2005) which will be discussed later in this report. Specific considerations include the small screen size, limited processor and graphics power, and the lack of a hardware keyboard for interaction with the device (Steve Yuen, 2004). Although several PDAs and Smartphones are produced with built-in miniature qwerty keyboards, and portable foldable and virtual keyboards (5, 6) are relatively cheap, but for wide-scale distribution it must be assumed that the target devices do not have access to a keyboard.

1.2 Scope and aims of project

The main aim of the project is to build an application that demonstrates how Text to Speech (TTS) and Speech Recognition (SR) can be used to enhance training applications delivered on PDAs, but TTS and SR alone cannot significantly improve mediocre training. Such features should only ever be used where they are going to satisfy at least one of the following criteria:-

1. Adding the features enhances the training value of the application.
2. Adding the features enhances the usability of the application
3. Adding the features provides something essential to the training (for instance TTS and SR can be essential tools for language lessons (7).

In the case of this project, all items in the list of criteria above are true.

1. Because the user will be able to practice listening to and talking to a simulation of an Air Traffic Controller (ATC), this represents a significant advantage over silent, text-based media.
2. Adding SR will make it possible to include voice commands to control the application, for instance making selections from a menu or paging forward through content.
3. With this specific project it is important that the user learns to pronounce certain words differently from normal English, for instance

the number *four* should be pronounced fowur and the number *nine* should be pronounced *niner* (8).

The target users of the software developed for this project are likely to be more motivated to use this software if it has TTS and SR than if it does not, whereas trainee accountants may well avoid such enhancements unless they have physical need for them, or the training developer was particularly innovative in the use of TTS and SR.

1.3 Success criteria

There are several items that represent a successful development outcome of the project.

1. Successful completion of the outline course content detailed in the Project Contract (*Appendix 1 Project Contract*).

2. Producing a course that is evaluated as an effective training application by sample users.

3. Successful inclusion of both TTS and SR throughout the course where required.

4. Inclusion of some TTS and SR in the course

5. Inclusion of SR as a navigational aid

6. Delivery of a useable and effective *proof of concept* and *demonstration application* to AC&S that they can use to demonstrate to prospective clients as an example of the software that can be produced for their needs.

It is possible that several criteria could be missing from the final evaluation, yet the final application is still judged a success.

2 Literature review

Mobile devices have become increasingly popular over the last 20 years as cell phone and PDA devices have advanced and converged. Educators have identified the potential for using these devices to deliver training to mobile users, giving rise to the term mLearning.

This review explores current literature to understand the “state-of-the-art” at the beginning of 2006, and discovers that mLearning is a highly active area of research which has yet to fully utilise all of the power and versatility of modern mobile devices. The paper concludes with a brief discussion on the future of mLearning.

2.1 Introduction

A search of literature relating to the development and delivery of training to PDAs revealed that the delivery of training to mobile devices is a highly active area of research. Available papers concentrate largely on training in schools and universities (for example Doug Peterson (January 2006) and David Pownell, Gerald D. Bailey (June, 2001)), with the exception of a small number of reports on the use of PDAs in museums and art galleries (Li-Der Chou et al (2002), Nancy Proctor and Jane Burton (May, 2003)) and one notable paper investigating self-created training in a hospital (Eva Brandt et al May 2003). The lack of commercial and business research references was disappointing, although if there had been a budget to pay for available commercial research that would not have been a problem.

Existing papers show research in several broad categories:-

- Collaborative learning
- The use of wireless technologies in the classroom to enhance learning and give teachers instant feedback on students’ understanding of the class (B. Craig Cumberland, et al (April, 2003), Susana M. Sotillo (May, 2003).

- Making existing desktop-targeted material available to mobile devices
- Education in a spatial context, e.g. museum tours, hospital and retail.
- Developing content specifically for mobile devices, in particular the MobiLearn project (C. O'Malley et al October, 2003).

This review looks at the existing research and adds the author's perspective as a long-term professional developer of computer-based and web-based learning for corporate clients, and also as a long-term avid user of PDAs.

2.2 Definition of a PDA

Apple's Newton, introduced in 1990, was probably the first device to be called a PDA (etForecasts, December 2003). A PDA is a Personal Digital Assistant, and according to Wikipedia (9) or Programmable Data Assistant according to one writer (etForecasts, December 2003). The accepted definition and the one most appropriate to typical users is the first definition. A PDA is a small, handheld electronic device that, at least, provides contacts, calendar and scheduling tools.

Modern pocketable electronic devices have advanced significantly since 1990, and many devices could be called PDAs. This section will briefly discuss current PDA devices and conclude with a definition of PDA for the purpose of this review, and for the entire report.

2.2.1 Mobile Phone

All modern mobile phones offer basic contact, calendar and scheduling features. Many provide additional features like a simple web browser that uses WAP technology (10), tools like a calculator and the ability to send SMS messages. They have small screens, typically monochrome or able to display 4096 colours at 96x68 pixel resolution (11). There will be no facility to expand storage space.

2.2.2 Smartphone

A search for a definition of a Smartphone revealed this definition:-

> A Smartphone combines the functions of a cellular phone and a handheld computer in a single device. It differs from a normal phone in that it has an operating system and local storage, so users can add and store information, send and receive email, and install programs to the phone as they could with a PDA. A Smartphone gives users the best of both worlds--it has much the same capabilities as a handheld computer and the communications ability of a mobile phone.

(12) Additionally Smartphones may have a camera capable of taking stills and short video clips, they may include features such as a radio or mp3 player and extended communication features like Bluetooth and GPRS or EDGE for high-speed data connections. Screens are usually larger than those on basic mobile phones, ranging up to 174x144 pixels for a phone like the Nokia 6682 (13). There may also be the facility to extend storage capacity for pictures and video via an SD or mini-SD slot (ref). Operating system is typically Symbian or a manufacturer's proprietary OS.

2.2.3 PDA Phone

A PDA Phone will combine all of the features of a full PDA and a Smartphone. Such devices include the Palm Trio 650 (14), HP iPaq hw6500 (15) and the HTC Universal (16). Screens sizes for these devices range from 240x240 pixels to full VGA 480x640, displaying 16-bit colour. They will use a PDA operating system like PalmOS or Pocket PC (variously named Windows Mobile, Pocket Windows etc). Native storage space is typically 32Mb to 128Mb and can be increased using Compact Flash, SD or mini-SD cards. A qwerty keyboard may be included.

2.2.4 True PDA

A 'true' PDA has no phone capability, but will probably have facility for wireless communication via Bluetooth and/or 802.11*x* Wi-Fi and infra-red. Screens range from 240x240 to 480x640 with 16-bit colour. OS will typically be PalmOS or Pocket PC, but PDAs using Linux have been made by Sharp (17). Typical PDA devices are iPaqs from Hewlett Packard (18), Dell Axims (19) and the Toshiba E800 (20).

2.2.5 Other devices

One device that could be considered a PDA is the OQO (21), but since this runs a full version of Windows XP it is not considered a 'true' PDA for the purpose of this report. There are also many Windows CE devices (22) and several Smartphones that run the Symbian OS (23) which are not considered PDAs under the definition used in this report.

One other new device deserves special mention. On January 4th 2006, DualCor Technologies Inc. announced a new handtop machine, the DualCor cPC, that simultaneously runs both the Windows XP Tablet Edition and Windows Mobile 5.0 operating systems (24, 25) *and* it is a cell phone too. This device signals a new phase in mobile computing which is being marketed to "medical and pharmaceutical industries, as well as retail, transportation and even government and military" (24), and of course the business professional.

2.2.6 Definition of a PDA used in this report

Defining a PDA is complicated by the fact that so many devices offer the most basic PDA functionality – a calendar and contacts database - and also so many devices combine features that are associated with other devices. With such a loose definition, Apple's iPod (26) is a PDA and a typical PDA is also portable a music player.

Many devices have features and functionality that cross the boundaries of the broad definitions listed above and much of the research material makes little

attempt to distinguish between them, which can create confusion. Paul Anderson and Adam Blackwood (November 2004) give an excellent, detailed description of PDAs and other similar devices, listing a larger number of device types than described here. This report gives similar definitions that are necessarily briefer and less exact, yet still adequately define PDA for our needs.

With such a wide range of devices with PDA functionality, this report needed to narrow the definition. When a general reference to PDA is made, devices listed in *2.2.3* and *2.2.4* will be what is being referred to. Where the specific target device of this project is being referenced, it will mean a Pocket PC device.

It is likely that many more of these devices will fully combine in the near future, making devices like the DualCor cPC familiar to us all. These devices will be what Paul Anderson (2004) calls PACE devices – Personal Assistant Communication and Entertainment devices, or perhaps, in light of the DualCor cPC, a new acronym is required; something like BIPACE - Business, Information, Personal Assistant, Communication and Entertainment.

2.3 Hardware Limitations and Advantages

PDAs have many hardware limitations, when compared to desktop computers and laptops (Yuen 2004). There are some significant advantages too, the most obvious of which are the portable size (Beverley Oliver and Corri Barrett, December, 2004), and the ability to be “instant-on” (Mary A.C. Fallon, January, 2006). The end of this section discusses ways to overcome some of the limitations set by the hardware.

2.3.1 Physical Size

The SMILE project (Sussex Mobile Interactive Learning Environment) (Rose Luckin, et al, May 2003) used XDA phone PDA devices (27) to deliver classes and to monitor collaborative efforts among the students. Students generally liked the XDAs, but complained:-

> When used as a phone the device was generally considered clumsy and too large, on the other hand the screen was too small to be used comfortably for the integrated Office functions.

In their study of mobile devices in language learning and history education (S. Savvas, et al, April, 2003) reported that younger users found the fine motor control when using a stylus challenging.

At Purdue University, an investigation into the use of PDAs "for quizzing functions in a large-enrolment course. Linked to WebCTs testing engine …" (Scott Homan, Kevin Wood, January, 2006) reported students complaining that the device was "too small for use as a quizzing tool". Perhaps their reliance on the relatively limited quizzing engine of WebCT was the real problem. Results may have been different if a different method had been employed to deliver the quizzes.

2.3.2 Screen Size and Resolution

The screen size of PDAs limits the amount of information that can be presented on screen (Yuen 2004). Stephen J.H. Yang et al (2003) reported that this presented problems for them when reformatting existing HTML content. "Navigation on mobile devices is cumbersome and time-consuming because of their limited screen size" (Paul Graham et al, May, 2003). Chris Noessel (May 2003) even said that the screen size *prevents* the delivery of engaging multimedia content.

In fact engaging content is entirely possible, but it requires more advanced tools than HTML editors to produce (Stephen J.H. Yang et al (2003), Marcus Ragus, (November 2004)) and skills not usually possessed by the teachers and researchers in academic studies.

One piece of software that is publicly available makes this point most emphatically – ExLib (28).

Fig 2 ExLib is an excellent example of high quality, engaging content

ExLib is not intended as 'engaging training', it is actually an exercise library, workout scheduler and progress diary. The desktop version is an interactive Flash (29) application. The PDA version is an exact mirror of the desktop version that is reformatted to present the information on the small screen of a PDA. Conversation by email with the developer of ExLib reveals that the same source swf (Macromedia Flash) files are used for both the desktop and the PDA version, with the only difference being the way that the content is presented to the user – i.e. the desktop version presents two panes of information simultaneously, whereas the PDA version can only show a single pane at a time.

ExLib demonstrates many of the key features of an engaging multimedia application, including the use of video to demonstrate correct form for the exercises described, and it uses an intuitive and attractive interface to give users easy access to a wide range of information. It is easy to see how methods used in ExLib can be utilised in other training and reference applications.

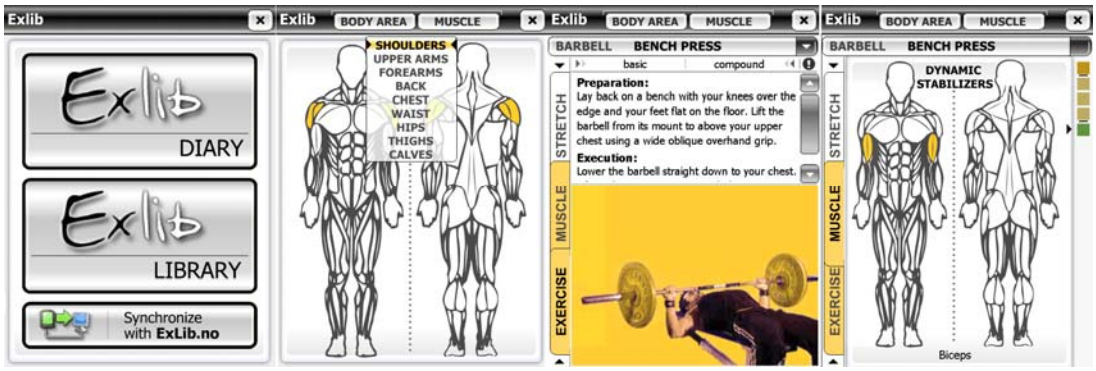

Fig 3 The PDA version of ExLib includes short videos showing correct form

2.3.3 Input methods

Several evaluations reported that PDA input methods were limiting (Kinshuk et al (2003), Tsvetozar Georgiev (June, 2004) and many others).

Little discussion was found about the other standard input methods of PDAs, Transcriber (for handwriting recognition), Block Recogniser and Letter Recogniser. These are all methods of converting hand-written characters to standard text.

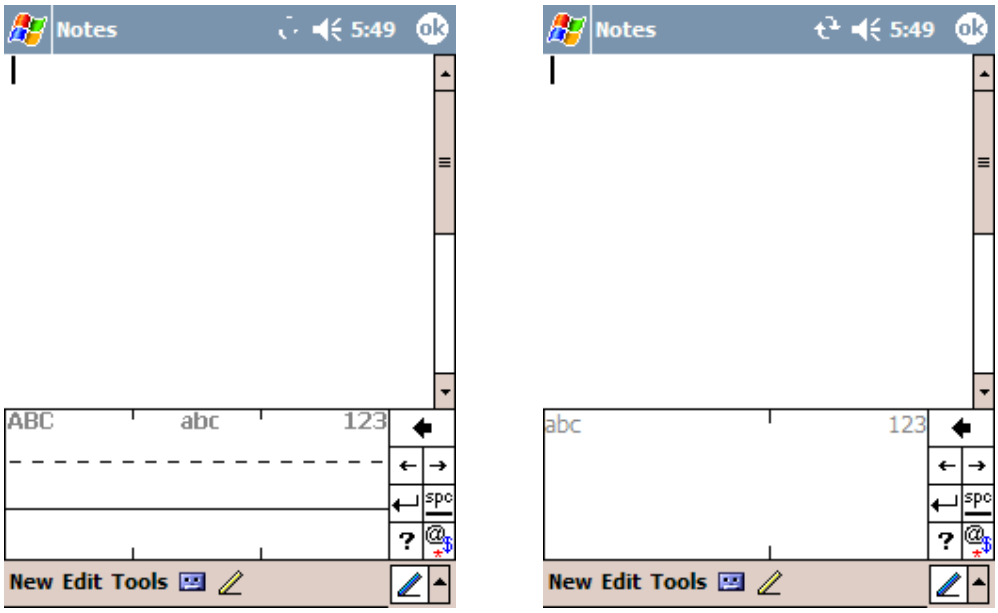

Fig 4 Input Methods, Letter Recogniser and Block Recogniser

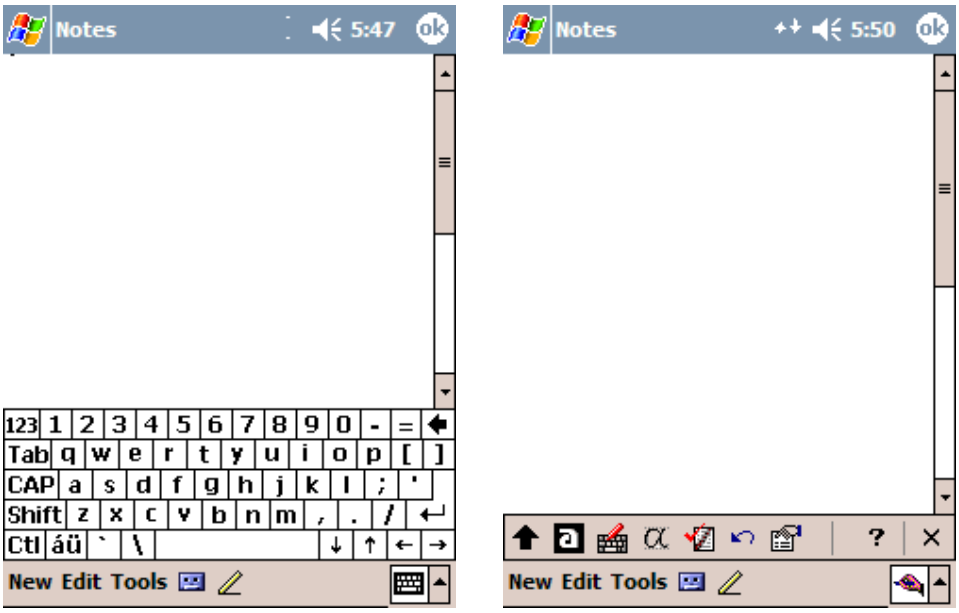

Fig 5 On-screen keyboard and Transcriber

All were in agreement that text entry speeds were a severe limitation for PDAs, although many researchers realised that an external keyboard could be utilised to enhance text input, e.g. Clark Quinn, PhD (January, 2006).

2.3.4 Software, Tools and Options to Overcome Limitations

It seems that most of the researchers are not familiar with all the features of PDAs and the tools available to make them more usable and to overcome their shortfalls. This is understandable as it is likely that many of the researchers had not used PDAs before starting their research, and it may not have been a requirement to look for third-party tools

Text Input Several 3rd-party input tools are available to enhance text input. Calligrapher (30) is an advanced version of Transcriber, the default handwriting recognition software in stalled on PocketPC devices. In addition to enhanced handwriting recognition, Calligrapher adds a macro feature that allows the user to add custom functions associated with specific writing, for instance the user can write the word “all” and circle it to select all the text on a page. Writing “copy” and circling it copies the text to the clipboard, and then , in another document, writing “paste” and circling it will paste the copied text.

Alternative on-screen keyboards are also available to speed up input. An excellent example of this is Fitaly (31), which has been proven to enable entry speeds as fast as 70 words per minute, as shown in the videos available on the Fitaly web site (32), although more typically, users can attain speeds 67% faster than the standard on-screen qwerty keyboard (Saied B. Nesbat, Ph. D.).

Fitaly is so-named because of the sequence of keys on the second row of the keyboard. This alternative keyboard layout is one of several, like the dvorak desktop alternative, that aim to increase typing ease and speed.

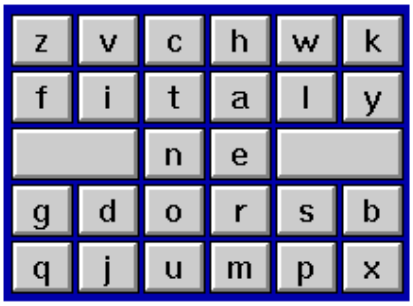

Fig 6 The Fitaly keyboard layout

2.4 Areas of Research

Published papers could be grouped into the following general categories.

2.4.1 Collaborative Learning

Studies like The Ambient Wood Project (Yvonne Rogers et al (2002)and The Remote Access Field Trip (RAFT) (Nick Hine et al May, 2003))are exciting examples of collaborative projects that utilise PDAs and other technologies to provide a rich and stimulating learning experience.

Along with other collaborative projects, they look at ways for students to access coursework (Yuan, 2004), attend classes remotely

> "Mmmm.... waking up almost an hour later than usual, looking at the slides while still in bed and listening to the audio over

> breakfast. Am now planning on taking the bus and continuing the lecture with my XDA ... how nice"

(Rose Luckin et all, SMILE (May 2003)), manage homework (Chris Houser et al (April, 2002)), share research (Mary Fallon (January 2006)) and complete projects. Evaluations of such studies are typically positive, but frequently de-emphasize the fact that PDAs are used more at the start of studies than at the end, suggesting an early novelty that wears out by the end of the study period (Louise Mifsud, 2004).

2.4.2 Classroom Enhancements

Using PDAs as a way to enhance the classroom experience has produced some interesting studies. Many have evaluated wireless communications to enable students to give teachers instant feedback about what they have learned in a class (Mary A.C. Fallon, January, 2006) by letting them anonymously respond to questions at the touch of a button. Teachers can adapt their classes during the lesson to take into account the number of correct responses.

2.4.3 Research Tools

Several studies concentrated on the use of PDAs as research tools. For the purpose of this study, these are unimportant because few are using the PDAs for the development and delivery of training. The exceptions are a VLE pilot study at Bristol University (Andy Ramsden, April, 2003) that uses Blackboard and Ohio State University Medical Center (Robert R. McKenney, 2004) who use AvantGo (33) to give students access to a course-specific web site and course documents. Since the delivery medium for each of these is HTML and other text-based documents (PDF, Doc etc) they are not interesting in terms of multimedia.

2.4.4 Training Applications

Eva Brandt et al (May 2003) studied hospital staff as they created actual training applications. Eva and her team had the innovative idea of having

hospital intensive care unit (ICU) staff create the training they needed in-situ by videoing themselves performing tasks and then revising content following peer review. Once this training was complete, it was loaded onto PDAs and the videos could be accessed by scanning barcodes near to the equipment.

Nancy Deviney and Christopher Von Koschembahr (February 2004) describe a major electronics retailer's system. They devised a system that proved that salesmen could be trained effectively, just-in-time using on-the-job training by accessing technical and marketing specifications of electronic goods simply by scanning their barcodes on the shelves. This proved preferable to the more traditional method of reading manuals in the office, remote from the device. Salesman could hold the device and interact with it while reading instructions and specifications. It also was shown that salesmen could get up to speed about products in real time as they were dealing with customers.

These applications are of particular interest in this report because they were also examples of training delivered in the exact location that it was appropriate. Both of these studies showed successful innovative used of PDAs for staff training, and represent some of the small number of commercial application studies referenced in literature.

There are many reasons why these two studies were successful. In the case of the ICU staff:-

- The self-made videos were peer reviewed for accuracy before being distributed. This made sure that the knowledge of all associated staff could be combined to get the most accurate information into the training.

- The use of video gave more information than a paper-based manual alone could.

- The act of making the videos ensured that all of those involved learned about the particular topic being filmed.

- Accessing the training while standing next to the equipment is better than reading about it in a manual, or trying to see and remember every step as they are demonstrated by a trainer.

For new users of a piece of equipment, placing the training beside the equipment (actually a barcode link that the PDA uses to select the appropriate video from memory), and using of video instead of a paper manual would have been the biggest contributors to successful training. Without the video, the training would have been no more effective than a carefully positioned manual (beside the equipment, not locked in a supervisor's office).

From the retailer's training program, salesmen were freed from reading thick manuals at a location remote from the devices they were trying to sell. Another feature of the PDA application enabled them to compare device features and functionality instantly as customers asked questions. Ultimately easy access to the manuals was the most important feature introduced by the system. Devices other than PDAs could have been used to achieve the same goal, but the approach was interesting and will lead to greater innovations in just-in-time training in the future.

2.5 Media Used to Deliver Training

The media used to deliver training can be broadly separated into two main areas, simple text and images, and multimedia. Following is a brief discussion of them.

2.5.1 Text and Images

Training experts do not recommend simple text and images when used for eLearning:-

> A large part of the initial hurdle [of] taking education online is the time required to repurpose content from traditional classroom delivery to online. Simple web-based page-turner developments merely take PowerPoint slides, blindly convert

> them to HTML, and call it Web-based training. This method is both common and produces large quantities of content, but has highly questionable learning value, especially among adult learners.

(Robert H Jackson, Web Based Learning Resources Library, 34)

However the majority of eLearning is text and images, as can be seen by the tools used to deliver training in the workplace. According to Brandon Hall, PowerPoint is the most frequently-used tool for creating e-Learning (Bryan Chapman, January 2006). Chapman reports that:-

- PowerPoint works well in specific environment and business conditions.
- The success of using PowerPoint is heavily influenced by your corporate learning culture.
- Converted PowerPoint content works well for specific topics, and not well for others.
- Organizations that are most successful don't try to view PowerPoint development as a holistic solution, but instead as part of a broader development toolkit.
- The greatest success is achieved by organizations who have a proactive plan for training the training developers (as opposed to just turning them loose to develop content in PowerPoint).
- Successful organizations standardize on toolsets that optimize PowerPoint source material for efficient online delivery and provide additional online learning capabilities such as testing, assessment, tracking results, etc.

(Anne Bliss, Ph.D. and Anne Heintzman, M.A , April, 2003) correctly point out that educators often do not have the skills to produce complex interactive training. Usually they do not have the time either. Tools and systems for creating training have evolved a lot over the last 20 years and productivity

has improved massively, but the tools and the methods used to get the best out of them take years to master, thus they remain in the hands of professional developers, leaving most professors and business educators to continue using simpler tools like PowerPoint.

But there are many innovative projects that have used text to great effect. Mobile phones are the target for the most interesting of these. (Elif Trondsen et al, February, 2004) describe how Japanese students can receive short English language lessons on their mobile phones via SMS. In Britain, (Jill Attewell, Carol Savill-Smith, May, 2003) described “instances of the use of SMS (text messaging) ‘soap operas’ to encourage pupils to revise early for examinations” by projects such as WAN2Lrn (35) and Geoff Stead (2003) reported that “Voice XML was used to deliver interactive stories or quizzes”.

2.5.2 Multimedia

(Sherry Hsi, 2002) and (Eva Brandt et al, 2003) made good use of video in their studies, especially (Brandt, 2003), as described above. The Tate Modern Multimedia project (Proctor and Burton, 2003) is going to add a BSL (British Sign Language) video element to their tour in the next phase. This is an innovative use of video, when it is more usual to give text only for hearing-impaired users.

(Sherry Hsi, 2002) and (Seth T. Raphael, May, 2002) are among many studies that report high success using audio and (Raphael) animations to augment their training applications. Raphael describes Math Blaster, and educational game that uses imaginative scenarios, bright, fun animations and a game scenario to successfully teach otherwise boring maths lessons. Rita Ribel Mitchell (“Summer” 2005), however, points out that only one girl in her class enjoys playing Math Blaster, as the rest do not. She says:-

> The boys choose Math Blaster or they go to the Internet to find one of their favorite game sites. As the girls draw pictures or write letters to their best friends, the boys are playing an updated version of Space Invaders.

> Whatever the real reason for the difference in program choice between boys and girls, it definitely seems to be gender based. The girls seem to view the computer as a tool and the boys seem to view it as a toy.

TTS and SR are being used in language lessons and electronic native- and foreign-language dictionaries (36, 37). Iraklis Paraskakis (2005) describes hypothetical scenarios in his Ambient Learning paper that include multi-format delivery of training, and he predicts that TTS will be an important technology for delivering training to busy executives who are driving or otherwise occupied in tasks that preclude reading, but not listening.

These and other studies show that the field of delivering interactive training to PDAs and other mobile devices is inspiring innovative methods of effectively delivering educational content of all sorts to mobile users.

2.5.3 “Lack of Didactical Fantasy”

Meisenberger and Nischelwitzer (Matthias Meisenberger and Alexander K. Nischelwitzer, September 2004) quote (R Schulmeister, 2001) when they say users of learning engines like their Mobile Learning Engine (MLE) suffer from a “Lack of Didactic Fantasy”. This means that training developers lack the imagination to produce engaging interactive training. Instead they produce training with dry text and images and multiple-choice quizzes. This is the true limitation to innovative training delivered via a computer device – if the training developer does not have an imaginative approach to using the training development tools, students will be given boring applications to learn from. Studies like (Alfio Andronico et al, 2004) “Designing Models and Services for Learning Management Systems in Mobile Settings” and (Andy Ramsden, April, 2003) (Bristol Universities VLE) show a great deal of innovation in the method of delivery, but lack imagination when it comes to content.

Mark Prensky (October 2001, December 2001) hints at reasons why this may be in his *Digital Native* series, and hints at how this may be remedied in the

future. In Prensky's model, Digital Natives are younger computer and device users who have grown up with sophisticated games and gadgets. Digital Immigrants are older users who have adopted the devices out of necessity, but have not truly adapted to them. Playing games for fun and to learn is second-nature to Digital Natives.

On the other hand, current educators are Digital Immigrants who were taught linearly, and whilst they know about less rigid learning methods, they have not truly embraced them, so they fall back on linear training because it makes sense to them. While Digital Immigrants enjoy a linear progression through their training, Digital natives are masters at multi-tasking and following multiple threads, and are more comfortable with navigating through multiple hyperlinks on a voyage of discovery than their older relatives.

This leads to the inevitable conclusion that training will become more innovative and less linear over the next few years as younger students become educators. It will be an exciting time in education, leaving older learners floundering rather like their parents do when asked to program the video recorder.

2.6 Training Delivered Via Internet Browser

2.6.1 Browser Limitations

The default Internet Explorer version installed on Pocket PC PDAs has a number of limitations, including:-

- There is no Java support (38)
- JavaScript support is limited to JavaScript version 1.1 (39)
- There is limited plug-in support (Marcus Ragus, November 2004)
- Small screen size makes viewing many web sites difficult, or impossible

- Poor support of Frames makes viewing sites that use frames cumbersome (Ragus, November 2004)

2.6.2 Browser Alternatives

AvantGo (33) is a subscription-based application that is used by a number of schools and universities to give students access to important content like coursework and schedules using dedicated, synchronised channels (Beverley Oliver, Fiona Wright, February, 2002). AvantGo allows users to download optimised off-line copies of web pages or entire web sites to their PDAs. Web pages are automatically synchronised when the PDA is connected to a host PC.

Opera (40) is developing a new browsers for Smartphone and Pocket PC that "opens up new possibilities for software based around Web services technologies." (Anderson, Blackwood, November 2004). Thunderhawk (41) and NetFront (42) offer subscription-based browsers and content that is compressed to make it more palatable to limited memory space, screen area and network connection speeds.

2.6.3 Improving the Browser Experience

There are many options and tools available that can significantly improve the experience of viewing content in a web browser on a PDA. Some are available for a small charge, for instance $20, and many are free.

- CSS (Cascading Stylesheets) can be used to build web pages that would automatically be formatted correctly for desktop or PDA screens. Support for CSS is limited on the PocketPC (43), but since CSS is designed to fail gracefully, content is still visible on PDAs if a particular feature is not supported. (43) Describes how PDA web browsing could be improved with better CSS support.

- The latest PDAs can change the screen orientation from portrait to landscape making hard-to-access web sites easier to read (figs 7, 8).

- Some higher-end PDAs have VGA screens, making the size of the viewable area much larger, thus making web browsing significantly more rewarding (figs 9, 10).

Each of these features makes viewing web pages easier without the need for reformatting of the source HTML. VGA screens, when using one of the many hacks available to force true VGA screen resolution, like SE_VGA and OzVGA (44 explains VGA settings in extreme detail) makes it possible to have a lot more content, and/or much greater detail on screen. Younger students with good eyesight are particularly likely to enjoy this feature.

Fig 7 Default view of Reuters web site, QVGA, portrait

Fig 8 Default view of Reuters web site, QVGA, landscape

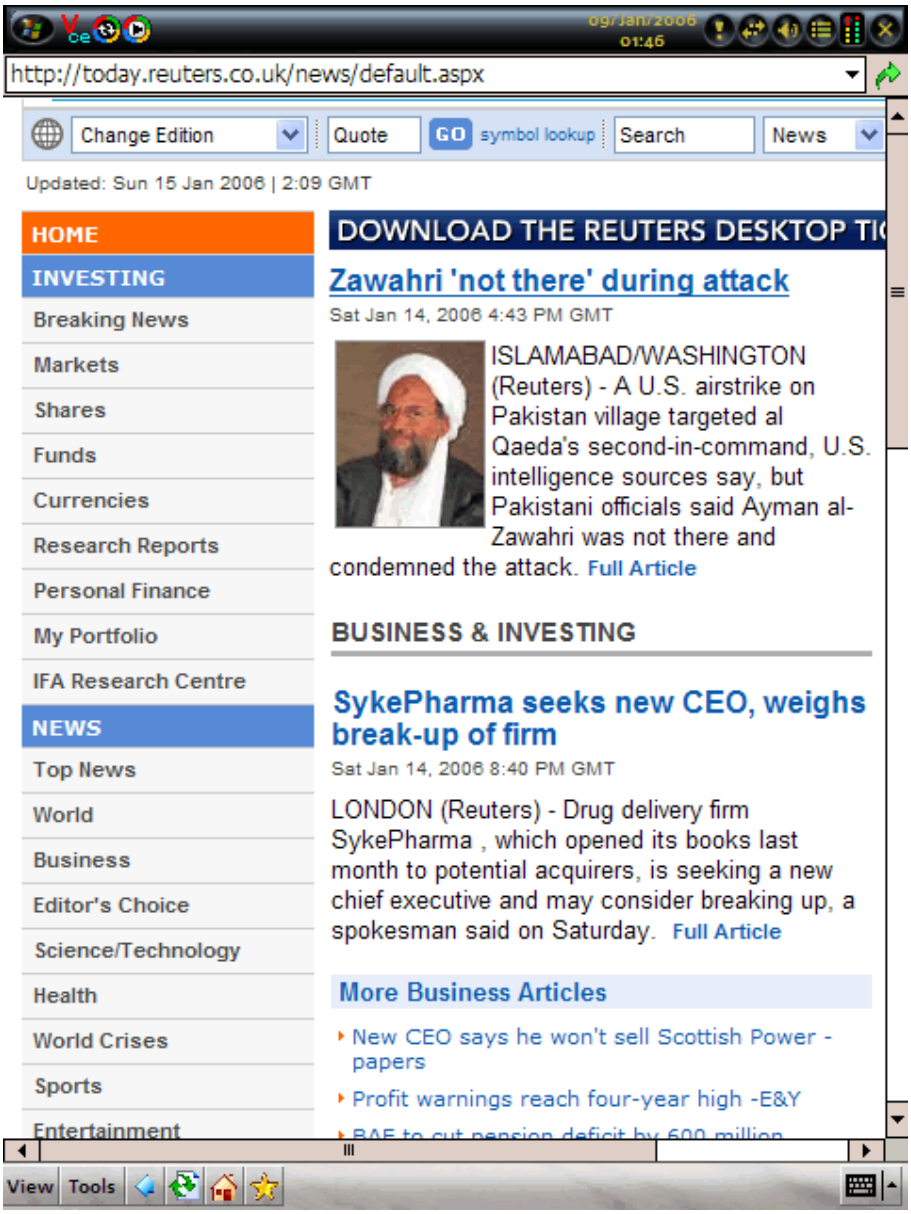

Fig 9 Default view of Reuters web site, VGA, portrait

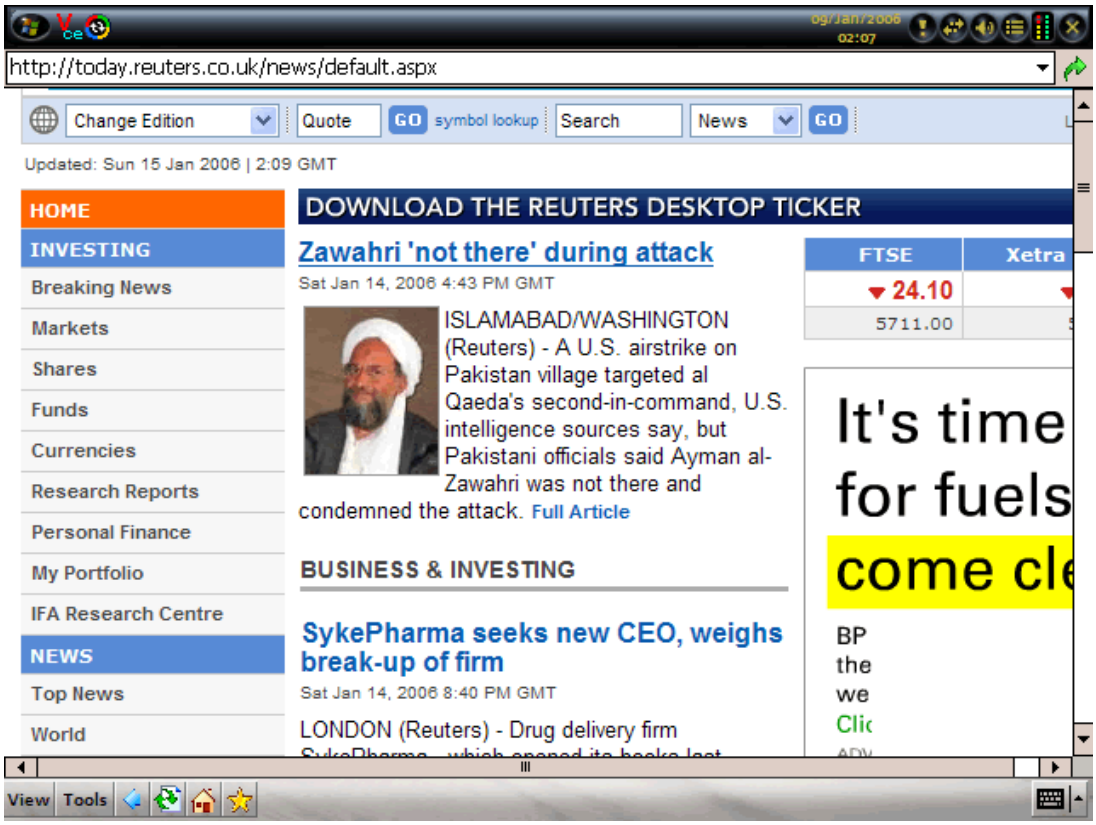

Fig 10 Default view of Reuters web site, true VGA, landscape

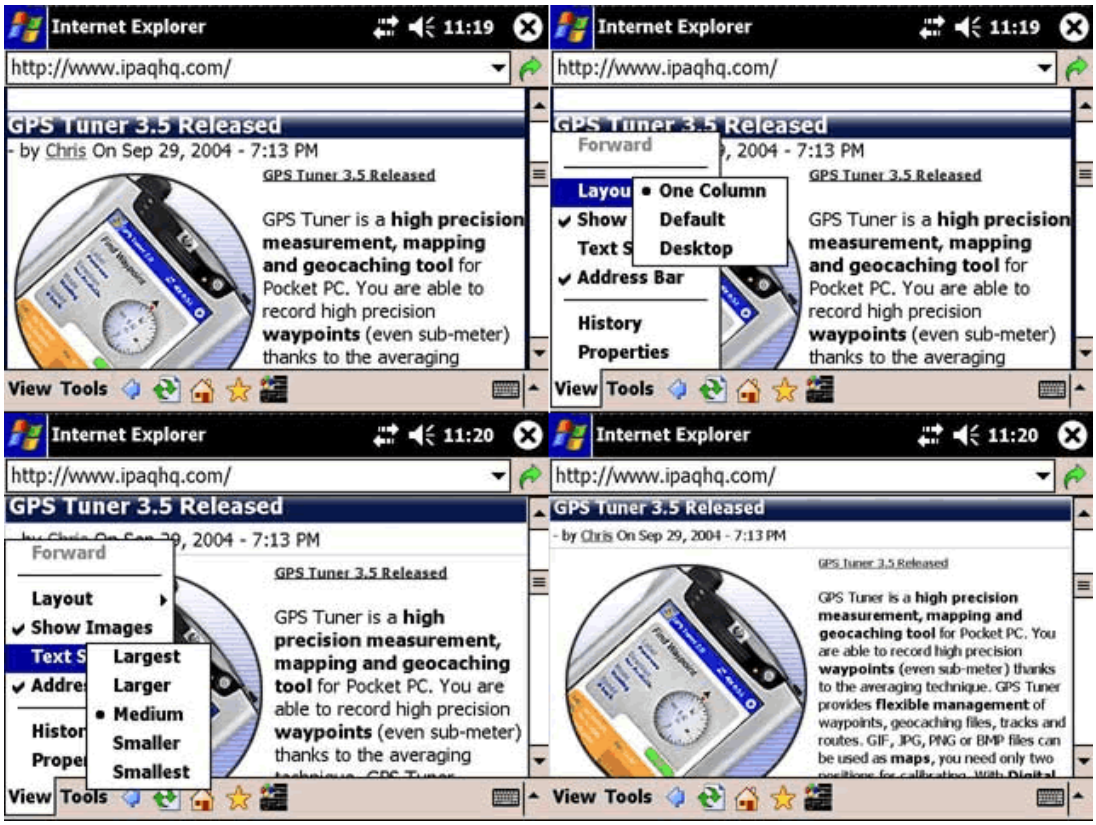

Fig 11 images from ipaqhq.com web site. QVGA, landscape, showing layout and text size options

- It is also possible to change the default text size and screen layouts on Pocket IE as shown above.

- (Brady, Conlan, Wade (May 2004)) referred to the need to avoid excessive vertical scrolling, a common guideline for training applications on PC too (Jonas Eklund et al, 2004). However (George Buchanan et al, May 2001) described vertical scrolling as preferable to horizontal scrolling and paging on mobile devices. In fact vertical scrolling is preferable to having to click on lots of links. On the PDA scrolling is made easy simply by clicking a directional button or a dedicated 'rocker' switch, and either of these is usually simpler to use than clicking on buttons or links using the stylus.

Users can find out about these and other tools by visiting software sites like www.handango.com or user forums such as www.pocketpcthoughts.com (46

is an excellent example). By using these and similar tools, many of the reported usability issues and development issues could have been remedied.

2.7 Tools for Creating Content

2.7.1 Ubiquitous Tools

These are defined as tools that all of us are familiar will, and include

- PowerPoint
- Microsoft Word (doc and rtf format)
- Acrobat Reader
- HTML editors

2.7.2 Specialist Tools

Steve Yuen (May 2004) describes a great many tools that are available for content development and delivery of training to PDAs in his lecture notes. These include tools for content delivery, tools for content presentation (e.g. presenting PowerPoint slides from PDA), calculators, quiz engines and document readers. Following is a sample of the tools listed:-

- Acrobat Reader for Palm (Palm & Pocket PC)
- AvantGo (Palm & Pocket PC)
- Documents To Go
- Presenter To Go (Palm & Pocket PC)
- Thought Manager
- Pocket Word and Pocket Excel (Pocket PC)
- IA Presenter (Pocket PC)
- Blackboard toGo

- Pocket slides by Conduits (Pocket PC)
- Pocket Slideshow by CNextX (Pocket PC)
- QuickPoint by Cutting Edge Software (PalmOS)
- Classroom Wizard
- QuizMe or QuizWiz
- Quizzler Pro
- Kaplan SAT Mobile (SAT * to Go)

The list shows there are many specialist tools available to assist in the creation and delivery of mLearning. These tools are all designed to be used without the need of advanced computing or development skills.

2.7.3 Professional Software Development Tools

Few studies discuss the professional developers' tools or technologies used to develop and deliver training. Those that did usually mentioned the ubiquitous tools already described. (S.Savvas et al, April, 2003) used Embedded Visual Basic (eVB) and Embedded Visual C++ (eVC) to develop their applications so they could utilise the multimedia capabilities of the PDAs to their fullest.

Macromedia's Flash was mentioned by several researchers including (Yang et all, 2003, C.E. Tapie Rohmet al, 2003) as a tool for creating advanced multimedia content for PDA. It is surprising that only a few researchers acknowledged Flash as a tool for developing mobile learning because

- 50% of eLearning developers report that they use Flash for content creation (Brandon Hall, 2005)
- Developers can use the same content developed for PC or Mac delivery and deliver it to PDA or Smartphone with few, if any changes to the source code

With Microsoft Visual Studio, the .NET framework is another advanced tool that can be employed to deliver multimedia content to a PocketPC PDA. Developers can use C# .NET and VB .NET to create .NET applications for PocketPC. The main advantage of using advanced tools like Flash, eVB, eVC and .NET is that they are more powerful and more versatile than less advanced tools like PowerPoint and Acrobat. This leads to the possibility of creating much more engaging and interesting multimedia applications. The disadvantage is that they require more skill and (generally) take more time to develop a similar amount of content.

2.8 Games

The MOBILearn project (46) emphasises

> product that is attractive to their particular target groups (principally the 15 to 24 year age bracket) and that engages them through multimedia activities and learning games.

(Ragus, November 2004)

Michael Culligan(2004) describes how the US armed forces use games extensively to train soldiers. Prensky (December 2001) reports that digital natives enjoy playing and learning from games. School studies show that younger students also enjoy games as learning tools (Raphael, May 2002).

Alice Mitchell (May 2003) reported that games were particularly popular if they had a competitive, and even a combative element. Mitchell also reported that girls were as likely to enjoy combative games as boys, counter to other studies like (Rita Ribel Mitchell, “Summer” 2005). The reason given for this was that other studies may have been too keen to apply preconceived stereotypical ideas of what boys and girls like.

All of the research agrees that games can be very effective in education provided educators take care to ensure that students are sufficiently motivated to complete the game, and that the game does not require so much skill that less adept game players fail to complete the course. Rita

Mitchell summarises her experience of gender differences and explains the importance of difficulty and motivation like this:-

> The most obvious example of gender differences in my computer lab is software preference. All of the students in every class seem to like using computers. We usually begin each period with keyboarding. Generally, the boys seem to have more difficulty bending their fingers and keeping them on home row. The keyboarding program allows students to progress to the next lesson as they meet the required accuracy score. As I walked around the room last Thursday, I noticed that most of the girls but only a few of the boys were on lessons six or higher.
>
> Then I watched as one girl's score was shown in red signifying low accuracy. She tried again. Again the score was red. She sighed and tried again. The boy sitting beside her also received a low score. He immediately pulled his hands away from the keyboard as though it was hot and muttered disgustedly, "I can't do this!" However during Math Blaster a few weeks ago the same boy persevered through a difficult phase of the game until he earned enough fuel to travel to the Trash Alien's home planet to rescue Blasternaut's robot companion.

(Siobhan Thomas, Gareth Schott and Maria Kambouri, May, 2003) described that gradually increasing difficulty the difficulty of a game while maintaining the "illusion of winnability" motivated players and kept their interest. They also found that the increase in difficulty should start gradually and build up to the hardest level, in preference to a linear progression of difficulty. This makes sense, as at the start of the game users are trying to complete the games challenges at the same time as learning how to play the game. As playing the game becomes easier, less effort is required for game-play and more of the students attention is available for learning.

All the studies looking at games in education report that they are a successful method of delivering training. Training developers should take care, though,

to ensure that the games are relevant and appropriate for the target audience. What works for high school students may not work so well for adult learners returning to education.

2.9 Conclusions

There are a great many studies that have been published or are underway, that are looking into using mobile devices to deliver training, to enhance the classroom experience, and even to use them to completely replace expensive desktop computers. Most of those studies are interested in the simple expedience of delivering the training, or in finding innovative ways to utilise the versatility of the PDA. They are all in agreement that, when used with care, the PDA can enhance learning for motivated learners.

The interest in mobile learning is fuelled by several main important factors

1. The use of computers has become accepted as normal, but they are expensive. Mobile devices are significantly cheaper than desktop computers, yet they offer similar processing power to the desktop computers of just a few years ago.

2. Ownership of such devices is increasing rapidly (4) and is expected to grow. Students are going to want to use them to assist their studies. The educational establishments are there to support and encourage such use.

3. Corporate educators also recognise and employ mobile devices as an important asset in their training systems.

Few studies are utilising the full power and versatility of PDAs to deliver the best training experience possible. For many, the reason for this is that they have concentrated on delivering content via internet, and thus the limited browser that is installed to the PDA by default. The availability of large, cheap memory cards should change that as educators realise that it is possible to break free from the limitations of the browser and network speeds to deliver highly interactive multimedia without concern for file sizes.

Macromedia announced a new version of Flash for mobile devices early in 2006, Flash Lite 2 (48). A list of supported devices on Macromedia's web site (49) indicates that phone manufacturers and Macromedia are working hard to ensure Flash will become as popular on mobile devices as it is on desktop machines. This means that the millions of existing Flash developers will be able to deliver engaging interactive content to phones using the same skills they already have for desktop development.

The next few years are going to continue to see vast changes in the power and utility of PDAs (4). When the Digital Natives get hold of these evolving devices, and tools like Flash, they are going to begin producing innovative training applications that will surprise the Digital Immigrants as they struggle to find the 'record' button.

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